THE ROLE OF TRAIT NEUROTICISM IN PREDICTING SUBJECTIVE FATIGUE STATES

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The Role of Trait Neuroticism in Predicting Subjective Fatigue States

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SUMMARY

Trait neuroticism, time of day, and day of the week were assessed as predictors of state fatigue. After completing an in-lab questionnaire, 176 participants ($N = 176$) reported their state subjective fatigue three times a day for 8 days. Trait neuroticism was shown to be a predictor of subjective fatigue states in the morning, early evening, at bedtime, and over the course of the 8-day study period. Additionally, results indicated statistically significant differences in subjective fatigue at different points in the day. A statistically significant Neuroticism X Day of the Week interaction indicated that the neuroticism – fatigue relationship was strongest on Tuesday and weakest on Sunday. The relative contribution of personality, time of day, and day of the week variables to state subjective fatigue are discussed.

CHAPTER 1

INTRODUCTION

According to Brown and Shutte (2006), subjective fatigue is a perceived state of "a pervasive sense of tiredness or lack of energy that is not related exclusively to exertion" (p.585). Several approaches to fatigue argue that this state results from the depletion of internal resources, which have been defined in general as "those objects, personal characteristics, conditions, or energies that are valued by the individual or that serve as a means for attainment of these objects, personal characteristics, conditions, or energies" (Hobfoll, 1989, p. 516). Limited resource perspectives have been influential in research areas as diverse as attention (Kahneman, 1973), task performance (Hockey, 1997), and worker well-being (Ziljstra & Sonnentag, 2006). Research studies adopting this perspective have frequently used time-on-task as a proxy for resource loss (e.g., Hockey & Earle, 2006) or analyzed levels of fatigue before and after an opportunity to recover from fatigue states, such as the weekend (Fritz & Sonnentag, 2005). While these methodologies allow the precise control of fatiguing circumstances and the analysis of predictors of recovery from fatigue states, they do not provide enough information to examine changes in the relationship between personality traits and fatigue states over the course of hours and days. Given research suggesting that the relationship between personality traits and various outcomes can be different at different times of day (Revelle, Humphreys, Simon, and Gilliland, 1980), it is important to analyze the extent to which the predictive power of different personality traits may change over the course of the day or week.

This paper will begin by describing several limited resource perspectives to fatigue. Next, applications of these theories to the study of time-on-task induced fatigue and the prediction of worker well-being over periods of days and weeks will be reviewed. Following this theoretical overview, extant research assessing the relationship between specific individual difference variables and subjective fatigue will be described. From this research review, trait neuroticism will be suggested as a particularly important individual difference variable to study in relation to subjective fatigue. After defining the construct of neuroticism, several lines of evidence will be presented which support neuroticism as a pervasive predictor of state subjective fatigue at multiple time points. The reviewed research will be used to justify specific predictions regarding mean differences in subjective fatigue over the course of the weekdays and weekend. Finally, existing research on trait neuroticism will be synthesized with limited resource perspectives to fatigue through specific hypotheses predicting a change in the relationship between neuroticism and subjective fatigue over the course of the day and days of the week.

Theoretical Perspectives to Fatigue

Research assessing time-on-task induced subjective fatigue has been influenced by Kahneman's (1973) limited resource conceptualization of attention. The theory specifies that people have a limited capacity to perform mental work which can be allocated among concurrent activities. An individual's overall level of arousal is related to his or her available attentional resources. Given that attention can be directed in multiple directions at any one moment, an allocation policy distributes resources to and away from a task. An individual's allocation policy is determined by enduring dispositions and momentary intentions, suggesting that both trait and situation variables may influence the allocation of attention. Evaluations of demands on capacity create a feedback loop to both the individual's arousal level and his or her allocation policy. The feedback loop influences both whether arousal levels must be increased or decreased and whether the attentional allocation policy needs to be changed to meet goals (Kahneman, 1973). The limited resource conceptualization of attention proposed by Kahneman has been used as the basis for research and theory in several areas of psychology (e.g., Furnham, Gunter, & Peterson, 1994; Matthews & Brunson, 1979).

Hockey's (1997) compensatory control model is a theory of subjective fatigue in time-on-task situations which has been influenced by limited resource theories of both attention (Kahneman, 1973) and working memory (Baddeley, 1999). According to the theory, performance on tasks is a result of comparing goal targets against feedback and adjusting effort output to minimize discrepancies. An executive control level is responsible for deciding whether to increase effort or reduce goal targets to minimize the discrepancy between goal targets and feedback when faced with an increased regulatory load (Hockey & Earle, 2006). Importantly for time-on-task fatigue, the executive control system is a limited capacity system, meaning that extended activation and cognitive interference can decrease effective functioning (Baddeley, 1999; Hockey & Earle, 2006). The theory proposes that sustained overuse of the executive control system results in feelings of subjective fatigue and decrements in performance stemming from fatigue.

Although the compensatory control model primarily focuses on variations in task performance, the model accounts for long term traits and states which may influence an individual's available resources prior to task performance. Similar to Kahneman's (1973) feedback loop, the executive control system contains an effort monitor which is responsible for managing effort during task performance (Hockey, 1997). The compensatory control model differs from Kahneman's theory by arguing that effort is not automatically increased to meet increasing demands. Instead, a perceived higher regulatory load causes executive control to be shifted from a lower, automatic level to a higher, effortful level. According to Hockey, this means that the effort monitor contains two separate levels, a lower and an upper set point. The lower set point is defined as the "default for a given task environment (the working effort budget), based on the anticipated resource needs of the task, level of skill, and so on" (Hockey, 1997, p.80). The upper set point is "an operational maximum for effort expenditure" (Hockey, 1997, p.80). Hockey argues that the difference between the effort monitor's lower and upper set points represents reserve effort which can be used to deal with additional task demands or high stress situations. Long term traits, such as capacity for sustained work and tolerance for aversive situations, and states, such as fatigue and mood, exert their influence on both the location of the upper set point and an individual's available reserve capacity. The compensatory control model uses task performance as an indicator of the functioning of the executive control systems, which is subject to the influence of both traits and states (Hockey, 1997).

A study by Hockey and Earle (2006) which assessed the compensatory control model recruited 24 secretarial staff and 25 graduate students to complete a series of primary office tasks, which were emphasized as a top priority, and secondary tasks, which were indicated to be necessary but low priority. Additionally, participants were given an open ended post-work task (searching for a hotel for the "manager" which meets certain criteria with no time limit). Participants completed measures of desire for control prior to engaging in office work and a brief mood scale (Hockey, Maule, Clough, & Bdzola, 2000). The Desire for Control scale (Burger & Cooper, 1979) assessed the extent to which people express a need to exercise control in their daily lives (Hockey & Earle, 2006), while the mood scale (Hockey et al., 2000) contained items assessing both fatigue and anxiety. A subsequent experiment was nearly identical in procedure, the exception being that control over tasks was manipulated by either allowing participants to plan the sequence and duration of their task activities (high control) or having their work schedules specified (low control). Results demonstrated that workload ($f = .62$) and personal control ($f = .52$) have significant main effects on subjective fatigue. Results also indicated that individual persistence on a post-work task was greater in conditions of high workload when participants had more control over their work schedule ($f = .47$) (Hockey & Earle, 2006). This study demonstrates empirical support for the compensatory control model.

Limited resource theories of fatigue have recently been extended beyond task performance research to examine fluctuations in worker well-being over the course of different time frames. Although this theorizing originated in the area of stress (Hobfoll, 1989), Sonnentag and her colleagues have developed a program of research analyzing the relationship between resource loss, recovery, and subjective fatigue. This research has primarily focused on the role of resource recovery, which is defined as a process of replenishing diminished resources (Ziljstra & Sonnentag, 2006). Empirical research has linked resource recovery to a number of negative fatigue-related outcomes. For example, recovery can reduce the impact of negative fatigue states on performance outcomes, evidenced by a positive relationship between recovery and task performance ($f = .28$) (Binnewies, Sonnentag, & Mojza, in press) and a relationship between recovery and lower levels of disengagement at work ($r = .23 - .38$) (Fritz & Sonnentag, 2006). At a worker well-being level, research has demonstrated an ameliorative effect of vacations on both self-reported exhaustion levels ($f = .50$) and health complaints ($f = .22$) (Fritz & Sonnentag, 2006).

The types of activities one engages in to recover resources over weekends and vacations can have an impact on the effectiveness of recovery opportunities in alleviating fatigue states. For example, participants in one study were asked to report the necessary level of effort expenditure required to fulfill their regular office tasks both before and after a vacation (Fritz & Sonnentag, 2006). Participants were also asked to report experiences during their vacation, including the extent to which they engaged in negative work reflection, which is defined as "thinking about the negative aspects of one's job and considering what one does not like about it" (Fritz & Sonnentag, 2006, p.937). Levels of trait negative affect (NA) were statistically controlled for in all analyses. Results indicated that participants who engaged in negative work reflection during their vacation reported that they had to expend more effort to accomplish their normal work tasks upon returning from their vacation (Fritz & Sonnentag, 2006). This effect was present after a couple of days ($f = .17$) and 2 weeks upon returning from vacation ($f = .40$). Additionally, participating in social activities during the weekend has been shown to predict general well being upon returning to work ($f = .58$) (Fritz & Sonnentag, 2005). Although some day level effect sizes are rather modest, studies which have analyzed the relationship between resource recovery and fatigue related outcomes over longer periods of recovery time, such as weekends and vacations, have typically found larger effect sizes (see Fritz & Sonnentag, 2005; Fritz & Sonnentag, 2006). Research has shown that certain situational variables, such as the types of activities engaged in over a weekend or a vacation, can play a role in the extent to which people recover from fatigue states (Fritz & Sonnentag, 2005; Fritz & Sonnentag, 2006). By extension, trait variables which predispose people to engage in negative work reflection or otherwise fail to properly experience recovery may indicate people likely to experience elevated levels of fatigue.

Individual Difference Variables and Fatigue

Although the research of Sonnentag and her colleagues has assessed fatigue from a contextual perspective, there has been less research assessing trait predictors of subjective fatigue in non-medical or clinical populations. However, there have been several studies assessing correlates of fatigue or fatigue in time-on-task situations which have illuminated numerous individual difference predictors of subjective fatigue states and fatigue related performance decrements. For example, a study by Revelle et al. (1980) sought to test the interaction between personality variables, time of day, and caffeine on task performance. The authors hypothesized that arousal levels related to caffeine intake and time of day effects would be differentially important to performance on a test with different levels of certain personality variables. In a series of five experiments, several personality and ability measures were administered to groups of university students and community members. Participants completed the experiment over two consecutive days. They were either given caffeine or a placebo and were tested in the morning or evening on each day. Each of the five experiments involved some variation of this basic design, using different personality variables and ability tests.

Results from these five studies indicated a series of complex interactions between caffeine, personality variables, time of day, and test performance. For example, participants scoring low on sociability performed better with caffeine in the morning but worse with caffeine in the evening. The opposite pattern emerged for participants scoring high on sociability (Revelle et al., 1980). Statistical analysis confirmed this Sociability X Caffeine X Time of Day interaction ($f = .71$). While this study specifically tested the relationship between arousal and testing performance, it is possible that time of day fluctuations in arousal based on personality are related to time of day fluctuations in fatigue. Studies are needed which directly test the impact of other trait variables on subjective fatigue.

Studies of fatiguing simulated driving have found relationships between trait variables and fatigue. A study by Thiffault and Bergeron (2003) administered personality trait measures to participants prior to completing two, 40 minute simulated driving sessions. One driving session was designed to be more fatiguing than the other, due to a more monotonous simulated environment. Driving fatigue was measured by the deterioration of steering skills over the course of the driving sessions, with increasing standard deviation of steering wheel movements (SDSWM) being indicative of increased driver fatigue. Results indicated an interaction between sensation seeking, extraversion, and SDSWM. Specifically, in the more monotonous driving condition, an individual's score on a sensation seeking scale predicted their SDSWM only if the participant scored high on an extraversion scale ($f = .27$). Scores on sensation seeking did not predict the SDSWM for less extraverted subjects in either of the simulated driving conditions (Thiffault & Bergeron, 2003). The results of several studies suggest that complex interactions between personality variables and fatigue can emerge over the course of a fatiguing task (Revelle et al., 1980; Thiffault & Bergeron, 2003).

Task-based studies of fatigue have also suggested a relationship between self-reported neuroticism and various objective and subjective indicators of fatigue. For example, Matthews and Desmond (1998) conducted a study of task-induced fatigue using a driving simulator. Participants completed several personality measures, including the Eysenck Personality Questionnaire (EPQ; Eysenck & Eysenck, 1972), prior to engaging in a series of two simulated driving sessions. Participants also completed a 24-item fatigue scale before and after the simulated drives which assessed symptoms of physical fatigue, perceptual fatigue, and boredom. Each participant completed one perceptually demanding, fatiguing condition and one control condition. Results indicated that neuroticism predicted post-task visual fatigue ($f = .22$), post-task malaise ($f = .17$), and post-task muscular fatigue ($f = .14$) (Matthews & Desmond, 1998). Interestingly, self-reported neuroticism also predicted pre-task visual and muscular fatigue; indicating that participants reporting high levels of neuroticism felt more fatigued than other participants before the task even began. This suggests that neuroticism may be an important individual difference variable in predicting subjective fatigue.

Trait Neuroticism

Neuroticism is a construct which has been defined in numerous ways. Various researchers have defined neuroticism as “the tendency to experience negative distressing emotions and physical symptoms” (Merkelbach, König, & Sittinger, 2003, p.198), “the general disposition to develop psychopathological symptoms such as anxiety and depression” (Muris et al., 2005, p.1106), and “a psychological tendency to perceive threat" (Schneider, 2004, p.801). Common to most definitions of neuroticism is a tendency to experience negative affect (Wilson & Gulloone, 1999) and to ruminate and worry (Eysenck, 1991; Muris et al., 2005). High levels of neuroticism have been linked to anxiety and depression (Muris et al., 2005), negative affect (Wilson & Gullone, 1999), burnout (Langelaan, Bakker, van Doornen, & Schaufeli, 2006), and distress (Bolger & Schilling, 1991). Additionally, low scores on neuroticism are negatively correlated with emotional exhaustion (r = -.12) and disengagement (r = -.23) (Tai & Liu, 2007). Neuroticism has been associated with negative mood states (r = .38) (Tamir & Robinson, 2004), daily distress (d = .59) (Bolger & Schilling, 1991), anxiety (r = .70), and depression (r = .54) (Muris et al., 2005). Important to the study of subjective fatigue is research which has shown that emotional stability (the other end of the continuum in many conceptualizations of neuroticism) is positively related to psychological detachment (Sonnentag & Fritz, 2007). Psychological detachment has been shown to relate to a number of resource recovery related variables, including morning serenity (r = .33) and morning negative activation (r = -.28), which represents feelings of tension, distress, and anger upon waking (Sonnentag, Binnewies, & Mojza, 2008). All of the aforementioned relationships indicate that people reporting higher levels of neuroticism may be particularly likely to experience elevated subjective fatigue.

Task based studies of neuroticism have suggested an interaction between neuroticism, information processing styles, and mood related variables. Key to this research area is the distinction between stimulus-dependent processing and executive processing. As described by Robinson, Wilkowski, and Meier (2006), stimulus-dependent processing emphasizes the current situational context and developing automatic stimulus-response associations. In contrast, executive processing is more effortful, controlled, and variable. These authors conducted a study which suggested that people who utilize an executive mode of processing, evidenced by higher reaction time variability in choice reaction time tasks, and report higher levels of neuroticism tend to report higher levels of state negative affect. While this research did not specifically analyze levels of state subjective fatigue, it is likely that a similar pattern of results would be observed for this construct given the contribution of sustained activation of the executive control system to fatigue (Hockey, 1997). Evidence indicating that neuroticism is a predictor of poor performance during tasks with changing workload conditions (f = .20 - .28) (Cox-Fuenzalida, Swickert, & Hittner, 2004) may indicate that people reporting higher levels of neuroticism tend to approach tasks from an executive mode of processing. It is conceivable that tendencies to process stimuli in this manner predispose people reporting high neuroticism to experience more subjective fatigue.

A separate line of task-based evidence suggests that higher levels of neuroticism are associated with superior performance in certain circumstances. For example, Tamir (2005) has argued that people with higher levels of neuroticism prefer to experience feelings of worry when anticipating a cognitively demanding task. In a series of experiments, undergraduate participants anticipated their preferred affective state during several tasks or completed tasks of various difficulties. Results from these experiments indicated that neuroticism significantly predicted a preferred emotional state of worry in cognitively demanding situations (f = .30 - .46). This study also indicated that adopting a worried emotional state enhanced the performance of participants reporting higher levels of neuroticism. Participants completed a set of anagram tasks of varying difficulty after being randomly assigned to either recall an event in their past in which they were worried or an event in which they were happy. Results indicated that recalling a worrisome event was associated with better anagram performance only for participants with higher levels of neuroticism (f = .47). Although these results indicate that worry may elevate the performance of people reporting higher levels of neuroticism, adopting a worried emotional state in response to a demanding environment will likely increase subjective fatigue. The stress associated with worrying will reduce an individual's resources to cope with other situations (Hobfoll, 1989), leading to increased feelings of fatigue (Zijlstra & Sonnentag, 2006). The coping strategies adopted by people reporting high levels of neuroticism will likely decrease available resources, potentially leading to a cumulative build up of fatigue over the course of the day and week.

Several studies have looked at time of day fluctuations in fatigue and affect in people reporting high levels of neuroticism. A study which assessed 35 nurses working periodic night shifts showed that neuroticism was a significant predictor of fatigue-inertia (r = .43) (Bohle & Tilley, 1993). Neuroticism has also been shown to positively correlate with a tendency to report negative affect peaks in the evenings (r = .39) (Rustings & Larsen, 1998). The results of studies assessing time-of-day fluctuations in fatigue and negative affect in participants reporting high levels of neuroticism suggest that neurotic individuals are sensitive to resource loss during the day, ultimately leading to an unpleasant mood at the end of the day (r = .39). Coupled with results which indicate that neurotic individuals tend to ruminate and worry about events in an anxiety-provoking way (Muris et al., 2005), higher levels of neuroticism may put people in a self-perpetuating cycle of insufficient recovery, stemming from an inability to detach from work. Previous research has indicated a negative relationship between psychological detachment and self reported fatigue when returning home (f = .62) and at bedtime (f = .46) (Sonnentag & Bayer, 2005). Additionally, reflecting negatively about one's work during vacation has been linked to health complaints (r = .39) and exhaustion upon returning from vacation (r = .44) (Fritz & Sonnentag, 2006). The tendency to ruminate and worry, and hence fail to detach from work, coupled with tendencies to experience and be more sensitive to daily stressors (Bolger & Schilling, 1991) may lead people with high levels of neuroticism to feel more fatigued at all points during the day due to resource loss and chronic inefficient recovery. Contrary to previous studies indicating a relationship between neuroticism and negative mood related variables at later points in the day (Bohle & Tilley, 1993; Rustings & Larsen, 1998), the current study predicts a positive relationship between neuroticism and fatigue at all points of the day and week. This leads to the following set of predictions:

Hypothesis 1: Neuroticism will be positively associated with overall self-reported fatigue levels over the course of a week (Anticipated r = .45).

Hypothesis 2: Neuroticism will be positively associated with higher self reported fatigue upon waking up in the morning (Anticipated r = .22).

Hypothesis 3: Neuroticism will be positively associated with higher self reported fatigue in the early evening (Anticipated r = .37).

Hypothesis 4: Neuroticism will be positively associated with higher self reported fatigue at bedtime (Anticipated r = .44).

In addition to looking at the extent to which neuroticism predicts subjective fatigue states, it is also important to analyze patterns of mean change in subjective fatigue over the course of the weekdays and weekend. An assumption in resource-based approaches to subjective fatigue is that resource loss will have a cumulative effect on fatigue if there is insufficient time to recover or elevated resource loss (Zijlstra & Sonnentag, 2006). To assess the extent to which high resource loss and insufficient recovery represent cumulative fatigue components, it is useful to compare fatigue levels on Monday (when participants have had Saturday and Sunday to experience resource recovery) with fatigue levels of Friday (when resource loss should be greatest due to cumulative resource loss over the course of the weekdays).

Resource based approaches to subjective fatigue also argue that leisure time contributes directly to recovery from fatigue states. Previous research has demonstrated that weekend experiences significantly predict exhaustion ($f = .26$) and poor general well being ($f = .32$) on the following Monday or Tuesday evening even after existing levels of exhaustion and general well being are controlled for (Fritz & Sonnentag, 2005). Non-work hassles significantly predict disengagement from work ($f = .40$) and poor general well being after the weekend ($f = .37$), while positive work reflection predicts lower exhaustion ($f = .37$) (Fritz & Sonnentag, 2005). To analyze if recovery from fatigue states occurs on the weekend, subjective fatigue levels will be assessed both before and after the weekend. In this analysis, the frequency of engaging in certain weekend activities will also be assessed to control for any specific activities which may lead to decreased or increased subjective fatigue following the weekend.

Mean levels of subjective fatigue over the week will be tested with the following two hypotheses:

Hypothesis 5: There will be higher levels of fatigue at the end of the weekdays than at the beginning of the weekdays (Anticipated *f* = .66).

Hypothesis 6: Mean fatigue levels will be lower after the weekend (Monday) than at the end of the weekdays (Friday) (Anticipated *f* = .37).

As neuroticism is associated with ruminating and worrying about events (Muris et al., 2005) and being sensitive to daily stressors (Bolger & Schilling, 1991), it follows that people reporting higher levels of neuroticism will experience higher levels of fatigue at later points in the day as they experience elevated resource loss and fail to effectively recover from fatigue states. Decreased efficiency in recovering from fatigue states should also lead to increased subjective fatigue over periods of days. Specifically, the relationship between neuroticism and state fatigue should increase over the weekdays as people reporting higher levels of neuroticism deal with the demands of the week and fail to effectively recover during leisure time. Also, given the relationship between neuroticism and the tendency to ruminate and worry (Muris et al., 2005) and the effects of negative work reflection on recovery (Fritz & Sonnentag, 2006), it is likely that people reporting higher levels of neuroticism will experience less recovery on the weekend than people who do not report high levels of neuroticism. The relationships between neuroticism and subjective fatigue over the course of the day and days of the week will be tested in the following hypotheses:

Hypothesis 7: The relationship between neuroticism and self-reported subjective fatigue will increase over the course of the day (Anticipated *f* = .32).

Hypothesis 8: The relationship between neuroticism and self-reported subjective fatigue will increase over the course of the weekdays (Anticipated *f* = .47).

Hypothesis 9: Weekend recovery experiences will have a lesser impact on lowering fatigue in people reporting higher levels of neuroticism (Anticipated $f = .39$).

CHAPTER 2

METHOD

Participants

Results of an *a priori* power analysis indicated that 150 participants would be needed to detect the smallest hypothesized effect in the current study (Anticipated $r = .22$, Power = .87). Recruitment flyers and an Experimetrix posting indicated that to be eligible to participate, participants had to be native English speakers (speaking English from age 6 or earlier), have access to a laptop computer during the day and in the evenings, and have at least one class every weekday (Monday through Friday). The study description informed participants that the study was designed to assess the relationship between attitudes, motivations, interests, and daily energy levels. The sample was composed of 177 participants who were recruited from undergraduate psychology classes at Georgia Tech. Out of the total sample, 101 participants (57.1%) were female and 76 (42.9%) participants were male. There were 3 participants (1.7%) who had full-time jobs and 53 participants (29.9%) who had part-time jobs. Although no primary study variables correlated with employment status, several variables included for construct validity purposes were significantly correlated with part-time employment. Openness to Experience was negatively correlated with having a part-time job ($r = -.25$, $p < .01$), while both Worry ($r = .21$, $p < .01$) and Emotionality ($r = .16$, $p < .05$) were positively correlated with having a part-time job. The mean number of hours worked per week for employed participants was 14.36.

There was 1 participant eliminated from the sample prior to data analysis for scoring three standard deviations below the mean on state fatigue at multiple time points.

Therefore, the final sample used for statistical analysis consisted of 176 participants (N = 176). At this sample size, the power of all statistical tests in the current study was .90 or greater.

A single item in the demographic section of an in-lab questionnaire asked participants to report if they were native English speakers. Four participants (2.3%) self-reported that they were not native English speakers. To determine whether non-native English speakers should be retained in subsequent analyses, a set of independent samples t-tests were conducted to determine if non-native speakers differed on any trait variables assessed in the study. The non-native English speakers were significantly less conscientiousness than native English speakers, $t\ (174) = 2.04$, $p < .05$, $d = 1.03$. Given that these samples do not differ on any traits involved in specific hypotheses, these four non-native English speakers were included in the final analysis.

Participants were required to bring a copy of their class schedule to an in-lab session to make sure that they had at least one class every weekday. Upon arrival at the laboratory session, any participant who did not have at least one class on every weekday was told that they could not participate. All 176 participants included in the final analysis had at least one class every weekday.

Procedure

Informed consent was obtained at the beginning of the one-hour in-lab session, which occurred on a Saturday morning. During the session, participants filled out a self-report questionnaire assessing personality traits from the Five Factor Model, general feelings of fatigue (trait fatigue), positive and negative affect, and levels of various motivational traits. The questionnaire took approximately 35 – 40 minutes to complete.

A description of each measure used in the study is included below. After all participants had completed the questionnaire, a brief demonstration was provided of how to access and complete an online scale which assessed current attitudes and feelings of fatigue (state fatigue). Participants were also given an instruction slip which contained the internet address of the online surveys and an individual user name and password to log-in to the surveys.

Participants received instructions to access and complete the online state fatigue and attitude scale three times a day for an 8-day period. The 8-day period began the Monday morning after their laboratory session and ended at bedtime of the following Monday. Every day during this time period, participants were instructed to access and complete the online scale: (a) upon waking (Morning), (b) between 4 p.m. and 7 p.m. (Early Evening), and (c) between 9 p.m. and midnight (Bedtime). Additionally, participants were instructed that they would be prompted to complete a weekend activities questionnaire in their web browser following completion of their final online state fatigue and attitude scale (Bedtime of the 8^{th} day of online assessment). Following the completion of the 8^{th} day of online state fatigue and attitude assessment, participants were mailed a debriefing form describing the purposes of the study.

Two steps were taken in an attempt to reduce the amount of missing data in the online assessments. First, assigned extra credit was prorated so that participants got 1 hour of extra credit for completion of the laboratory session and .08 hours of extra credit for each online scale they completed, including the weekend activities questionnaire. Second, participants received an e-mail each morning at 5 a.m. which reminded them of their continued participation in the study and contained both a link to the online survey and their individual user name and password.

Data collection began in October of 2008 and ended in April of 2009. Because of this data collection time frame, the 8-day online state fatigue and attitude assessment occurred during a variety of points in the semester over the course of the study. All in-lab sessions were scheduled so that the 8 days of state fatigue assessment would not conflict with any university holidays.

Measures

Item-means, standard deviations, and coefficient α for all measures contained in the in-lab questionnaire are displayed in Table 1. Internal consistency estimates for all measures used in the in-lab questionnaire were acceptably high (all α's ≥ .78).

In-Lab Questionnaire Measures

Neuroticism measures.

Trait neuroticism was assessed using the neuroticism subscale of the Eysenck Personality Questionnaire (EPQ-N; Eysenck & Eysenck, 1972), as used in Wilson and Gullone (1999), and the neuroticism subscale of the International Personality Item Pool-NEO (IPIP; International Personality Item Pool, 2008, March 11). The long form of the EPQ-N consists of 23 items which ask participants to respond to a series of statements with a yes or no answer. Two items ("Do you often feel listless and tired for no reason?" and "Are you sometimes bubbling over with energy and sometimes very sluggish?") were not included in the scale due to potential overlap with the construct of subjective fatigue. To be consistent with other scales used in this study and to allow more precise quantification of self-reported neuroticism, participants were asked to indicate the degree

Table 1

Observed Correlations between Traits Measured with In-Lab Questionnaire and Trait Neuroticism

Variables	# Items	*M*	*S.D.*	α	*r*
1. Extraversion	20	3.97	1.24	.93	-.32*
2. Conscientiousness	20	4.46	1.11	.91	-.28*
3. Agreeableness	20	4.38	1.16	.84	-.42*
4. Openness to Experience	20	4.30	1.33	.83	-.07
5. Positive Affect	10	3.60	.94	.83	-.49*
6. Negative Affect	10	1.95	.93	.78	.70*
7. Desire to Learn	8	4.39	1.09	.81	-.14
8. Mastery	8	4.44	1.05	.80	-.13
9. Other Referenced Goals	7	4.07	1.13	.87	.23*
10. Competitiveness	6	3.57	1.34	.89	.04
11. Worry	10	3.84	1.27	.88	.67*
12. Emotionality	9	3.15	1.33	.83	.76*
13. Fatigue	16	2.95	1.40	.88	.58*
14. Neuroticism	20	2.92	1.40	.96	-

Note. Trait neuroticism scores were formed by summing scores on the IPIP – Neuroticism subscale and the EPQ – neuroticism subscale. Reliability estimates are based on all completed questionnaires ($N = 177$).
$^*p < .05$.

to which they felt each statement was true or untrue of them on a Likert-scale ranging from 1 (*Very UNTRUE of me*) to 6 (*Very TRUE of me*). A sample item is "I worry about things that I should not have done or said." Test-retest reliability for the EPQ-N scale has been shown to be .87 in the short term (a few weeks) and .62 over a long time period (19 years) (Birley et al., 2006). Studies aimed at assessing the factor structure of the EPQ have shown that the items of the neuroticism subscale load on a neuroticism factor (Ivkovic et al., 2007).

The neuroticism subscale of the International Personality Item Pool-NEO (IPIP-NEO) is a 20 item measure which asks participants to rate on a scale from 1 (*Very inaccurate*) to 5 (*Very accurate*) the degree to which they feel a statement describes them. The 20 item version of the IPIP neuroticism subscale contains 10 negatively worded and 10 positively worded items (reverse scored). To prevent participants from having a neutral scale point and to be consistent with the version of the EPQ used in this study, the response options were converted to a Likert-scale ranging from 1 (*Very UNTRUE of me*) to 6 (*Very TRUE of me)*. A sample item is "I rarely lose my composure (reverse scored)". The IPIP-NEO has shown high convergent validity with other measures which assess Five Factor personality traits (r = .73 for the NEO PI-R) (Goldberg, 1999) and has been used extensively in research (Goldberg et al., 2006). A copy of this scale as used in the current study is included in Appendix A.

The EPQ and IPIP neuroticism subscales were summed into a total score representing overall levels of trait neuroticism prior to statistical analysis. These scales were combined for two reasons. First, the underlying theory of the EPQ was developed from a clinical framework, with people high in neuroticism having highly reactive autonomic nervous systems (Eysenck, 1967). Given that the current study assessed subclinical levels of neuroticism, the inclusion of a scale developed to assess non-clinical personality traits is necessary. Second, the inclusion of a greater number of items increased the internal consistency of the measure (α = .96 for the combined scale). Statistical evidence indicates that it is appropriate to combine the items from these scales into an overall scale score in the current study. In addition to the high internal consistency of the combined scale score, the correlation between scores on the EPQ and IPIP neuroticism subscales was very high ($r = .84$, $p < .01$).

Trait fatigue measure.

Participants completed an adapted measure combining 11 items from the Chalder et al. (1993) Fatigue Scale (CFS) with five items from the Checklist of Individual Strength (CIS; Vercoulen et al., 1994). In its full form, the CFS is a 14 item measure with 8 items assessing physical symptoms of fatigue and 6 items assessing mental symptoms of fatigue. Participants are asked to identify the presence of these 14 symptoms with yes or no responses. To be consistent with other scales used in the in-lab questionnaire and to allow more precise quantification of self-reported trait fatigue, items were converted from yes/no questions to statements which participants were asked to rate in terms of how they generally feel on a scale ranging from 1 (*Strongly Disagree*) to 6 (*Strongly Agree*). One physical fatigue item ("Do you start things without difficulty but get weak as you go on?") and two mental fatigue items ("Do you find it more difficult to find the correct word?" and "Have you lost interest in the things you used to do?") were not included in the scale used in this study because they were vague and tapped more clinical symptoms of fatigue. The items from the physical and mental fatigue scale were combined into an overall fatigue score to increase the internal consistency of the measure.

Given the brevity of the CFS (Chalder et al., 1993), five additional items adapted from the Checklist of Individual Strength (CIS; Vercoulen et al., 1994) were also included in the trait fatigue scale used in this study. In its full form, the CIS is a 24 item scale assessing several aspects of subjective fatigue. Internal consistency estimates on the full form of the measure have been shown to be high in previous studies ($\alpha = .90$; Vercoulen et al., 1994). Scores on this measure have been shown to be related to a number of different fatigue related variables, including sleep disturbances, social functioning, and functional impairment (Vercoulen et al., 1994).

Construct validity measures.

Given that the neuroticism scale used in this study was a composite of two well-validated measures which have not previously been combined in research, a set of measures were included in the in-lab questionnaire to asses the convergent and discriminant validity of the neuroticism scale.

As previous studies have demonstrated intercorrelations amongst Five Factor personality variables (Hong, Paunonen, & Slade, 2008; Seeman et al., 2005), the 20 item scales of the IPIP-NEO assessing Extraversion, Conscientiousness, Agreeableness, and Openness to Experience traits of the IPIP-NEO were also included in the in-lab questionnaire. As with the neuroticism scale, participants were asked to rate on a scale ranging from 1 (*Very UNTRUE of me*) to 6 (*Very TRUE of me*) the extent to which they felt that a given statement was true of them as they generally are. A sample Extraversion item is "I feel comfortable around people." A sample Conscientiousness item is "I pay attention to details." A sample Agreeableness item is "I believe that others have good intentions." A sample Openness to Experience item is "I believe in the importance of art" (IPIP, 2008, March 11). Studies which have used several measures of the Five Factor personality variables have generally found a negative correlation between neuroticism and the traits of extraversion, agreeableness, and conscientiousness (Hong et al., 2008; Seemann et al., 2005). Replicating this pattern of correlations will provide convergent validity evidence for the composite neuroticism scale used in this study. Small or non-significant correlations have generally been found between neuroticism and the openness to experience trait (Hong et al., 2008; Seemann et al., 2005). A non-significant correlation between neuroticism and openness to experience in the current sample will provide discriminant validity evidence for the neuroticism scale used in this study.

Participants also completed measures of trait Positive and Negative Affect (PA and NA) using the Positive and Negative Affect Schedule (PANAS; Watson, Clark, & Tellegen, 1988). The trait version of the PANAS contains 10 adjectives associated with PA and 10 adjectives associated with NA. Participants were asked to indicate the extent to which each adjective describes the way they feel in general on a scale ranging from 1 (*Very slightly or not at all*) to 5 (*Extremely*). This scale has been used extensively in research and has consistently demonstrated a two-factor solution representing the dimensions of PA and NA (McNiel & Fleeson, 2006; Tamir & Robinson, 2004; Watson et al., 1988). Additionally, this scale has been validated for use at both trait and state levels (Watson et al., 1988). Test-retest reliabilities for the trait version of both scales have been shown to be acceptable over an 8-week time interval (PA $r = .68$, NA $r = .71$)

(Watson et al., 1988). Empirical research has found a meaningful relationship between neuroticism and negative affect using a variety of measures (see Wilson & Gullonne, 1999). Conversely, research has found a negative relationship between trait neuroticism and trait PA in a young adult sample (Wilson & Gullonne, 1999). A positive correlation between neuroticism and NA and a negative correlation between neuroticism and PA will provide convergent validity evidence for the neuroticism scale used in this study.

The final measure included in the in-lab questionnaire was the short form of the Motivational Trait Questionnaire (MTQ; Heggestad & Kanfer, 2000). This is a 48 item measure assessing six motivational traits which map onto three underlying factors: Personal Mastery (Desire to Learn, Mastery), Competitive Excellence (Other Referenced Goals, Competitiveness), and Anxiety (Worry, Emotionality). Participants rated the extent to which they felt each statement was true of them on a scale ranging from 1 (*Very UNTRUE of me*) to 6 (*Very TRUE of me*). The Worry and Emotionality scales of the MTQ have been correlated with neuroticism in previous research (Heggestad & Kanfer, 2000). Replication of these correlations will provide convergent validity evidence for the neuroticism scale used in this study. The other four scales of the MTQ (Desire to Learn, Mastery, Other Referenced Goals, and Competitiveness) have been shown to have negligible correlations with neuroticism (Heggestad & Kanfer, 2000). Finding non-significant correlations between these four scales of the MTQ and neuroticism will provide discriminant validity evidence for the neuroticism scale used in this study.

As can be seen in Table 1, the pattern of observed correlations provides evidence for the convergent and discriminant validity of the neuroticism scale used in the current study. The correlations of Extraversion (r = -.32), Conscientiousness (r = -.28), Agreeableness (r = -.42), PA (r = -.49), NA (r =.70), Worry (r = .67), and Emotionality (r = .76) with Neuroticism were all significant (p < .01) and in the predicted directions. These correlations provide strong evidence for the convergent validity of the composite Neuroticism scale used in this study. The correlations of Openness to Experience (r = -.07, n.s.), Desire to Learn (r = -.14, n.s.), Mastery (r = -.13, n.s.), and Competitiveness (r = -.04, n.s.) with Neuroticism were all negligible and non-significant as predicted. The observed pattern of small to non-significant correlations between these traits and neuroticism is consistent with prior research (Hong et al., 2008; Heggestad & Kanfer, 2000; Seeman et al., 2005). Contrary to expectations, the correlation between Neuroticism and Other Referenced Goals was statistically significant (r = .23, p < .01). Although not as strong as the evidence for convergent validity, these correlations provide some support for the discriminant validity of the Neuroticism scale used in this study. Taken together, these results provide supportive evidence for the construct validity of the combined Neuroticism scale.

Online Measures

State Fatigue and Attitudes.

The 26 item measure completed by participants three times a day over the 8-day study period contained state versions of two scales completed in the In-Lab Questionnaire. In contrast to the trait scales, participants were instructed to respond to the items in terms of how they currently felt for the state scales. Sixteen of the items included in the online scale were the same items used to assess trait fatigue, altered to reflect current feelings (Chalder et al., 1993; Vercoulen et al., 1994). A sample alteration from trait to state assessment is changing “I have difficulty concentrating” to “I am having difficulty concentrating." Although relatively low because participants were asked to indicate current feelings, average *r*-to-*z* transformed test-retest reliabilities for the state fatigue scale in the morning, early evening, at bedtime, and over the course of the 8-day study are included in Table 2. Item-level means and standard deviations for these specific time points are also included in this table. The other 10 items of the 26 item online scale were adapted from the state PA scale of the PANAS (Watson et al., 1988). These items were included to reduce the transparency of the assessment of state fatigue for participants.

Many participants did not complete several of their state fatigue and attitudes assessments within the indicated time windows (Upon waking, Between 4 p.m. and 7 p.m., and Between 9 p.m. and midnight). Out-of-range responses were recorded as belonging to the nearest required time point provided that they did not fall within 1 hour of any other required time point. Out-of-range responses which could not clearly be

Table 2

Item-Level Means, Standard Deviations, and Average Test-Retest Reliabilities for State Fatigue Measurement

Time Point	*M*	*S.D.*	*Average Test-Retest Reliability*
1. Morning	3.11	.94	.51
2. Early Evening	2.79	.84	.45
3. Bedtime	3.16	.84	.43
4. Overall	3.02	.89	.46

Note. Averages are based on *r*-to-*z* transformed correlation coefficients.

assigned to a specific required time point in this manner were not included in the final data analysis.

Weekend Activities Questionnaire.

Following completion of their final online self-reported fatigue and attitudes assessment, participants were prompted to complete a questionnaire developed for this study assessing the frequency with which they had engaged in specific activities over the previous weekend. Participants indicated which days, if any, in the previous weekend they had engaged in 22 different activities on an 8-point scale containing all possible combinations of weekend days. A copy of the 22 item Weekend Activities Questionnaire is included in Appendix B.

The day after the 8-day study concluded, data files were checked and an e-mail was sent to anyone who failed to complete the Weekend Activities Questionnaire following the final online state fatigue and attitudes assessment. The e-mail informed participants that they could log back in to the system and complete this measure by the end of the day on Tuesday. In total, 155 of the 176 participants (90.1%) completed the Weekend Activities Questionnaire.

An analysis was run on these 155 participants to determine if engagement in any specific weekend activities needed to be statistically controlled for in any analyses pertaining to weekend fatigue effects. As no specific directionality was predicted and to account for multiple unplanned tests, a significance value of $p < .01$ was used. Self-reported engagement in each of the activities listed in the Weekend Activities Questionnaire was dummy coded (0 = Did not report doing, 1 = Did report doing) and correlations were computed between each of the 22 listed activities and state fatigue on each weekend day. Significant correlations were then further analyzed to determine if engaging in any activities on any specific day or combination of days was significantly correlated with state fatigue after the weekend (Monday). This analysis indicated that there was a small but significant correlation between engagement in a hobby on Saturday and fatigue after the weekend ($r = .18$, $p < .01$). Participants who engaged in a hobby on Saturday were more likely to report higher levels of fatigue Monday. However, this effect was not controlled for in any subsequent analysis due to both the small magnitude of the effect and the small number of participants who reported engaging in a hobby on Saturday only ($n = 10$, 6.5% of those who completed the Weekend Activities Questionnaire).

Analysis

Prior to analysis, the skewness and kurtosis of all study variables were examined. No skewness absolute value was greater than .88 and no kurtosis absolute value was greater than 1.3. Both of these values fall within Kendall and Stewart's (1958) recommended acceptable range (Skewness < 2 and Kurtosis < 5). Additionally, the impact of skewness and kurtosis on results is lessened with larger sample sizes (Tabachnick & Fidell, 2001). Inspection of frequency plots did not suggest any variables which clearly deviated from normality. Therefore, all variables were analyzed in their original metric.

To assess whether self reported neuroticism was a significant predictor of state fatigue at different time points, separate scores for morning, early evening, bedtime, and overall fatigue were calculated by summing all state fatigue scores at the appropriate time point. A series of Ordinary Least Squares (OLS) regression analyses with neuroticism as the predictor variable and subjective fatigue at these time points as the criterion variable were conducted to test the significance of Hypotheses 1 – 4. Although previous studies have suggested that women have a higher tendency to worry (Muris et al., 2005) and feel fatigued at bedtime (Sonnentag & Bayer, 2005), the average *r*-to-*z* transformed correlation between sex and fatigue at any time point was not statistically significant (average $r = -.13$, n.s.). These low correlations are consistent with evidence which suggests that fewer sex differences in fatigue appear in more homogenous samples (Lewis & Wessely, 1992), such as a college student population. Given this low correlation, sex was not statistically controlled for in any regression analyses in the current study.

A regression analysis using planned contrasts was conducted to test Hypothesis 5. Although Cohen, Cohen, West, and Aiken (2003) recommend testing this type of effect using three planned contrasts (Thursday and Friday vs. Monday and Tuesday, Monday vs. Tuesday, and Thursday vs. Friday), a fourth orthogonal planned contrast was included to ensure that state fatigue on Wednesday was not different from state fatigue on any other weekday. Orthogonal contrast codes for this analysis are included in Appendix C.

To assess whether there is an ameliorative effect of weekend experiences on levels of fatigue, a paired *t*-test was conducted which assessed whether mean fatigue levels are lower on the second Monday than they are on Friday evening. This analysis allows the test of Hypothesis 6.

To analyze whether the relationship between neuroticism and fatigue strengthens over the course of the day, a split plot multivariate ANCOVA with fatigue at each of the three time points as the dependent variable and self-reported neuroticism as a covariate was conducted. Although potentially less powerful, the multivariate version of the split plot test does not require the sphericity assumption present in univariate designs which have within subjects effects (Stevens, 2002). Given that violations of the sphericity assumption can positively bias the *F* ratio (Box, 1954) and that adjustments to the *F* ratio to account for sphericity in univariate tests can be quite conservative (Stevens, 2002), the multivariate approach to repeated measures is preferable to the univariate alternative. Pillai's Trace will be used to evaluate the significance of main effects and interactions in this ANCOVA, as this test statistic is fairly robust to test assumption violations (Stevens, 2002). The Time of Day X Neuroticism interaction will test the significance of Hypothesis 7.

To analyze whether the relationship between neuroticism and fatigue strengthens over the course of the week and weakens over the weekend, a split plot multivariate ANCOVA with fatigue on each of the 8 days as the dependent variable and self-reported neuroticism as a covariate was conducted. As with Hypothesis 7, Pillai's Trace will be used to evaluate the statistical significance of main effects and interactions. The Day of the Week X Neuroticism interaction and the single-*df* quadratic within-participant contrast test will assess the significance of Hypotheses 8 and 9.

CHAPTER 3

RESULTS

Missing Data Analysis

Although participants were sent reminder e-mails each morning, some participants failed to complete a significant number of the online scales. The percentage of missing data at each time point is included in Table 3 for the weekdays and in Table 4 for the weekends. The 1 outlier discarded in subsequent analyses was included in the missing data analysis in an effort to accurately characterize missingness in the complete sample. The total amount of missing data in the entire sample for state measures was 19.40%. Additionally, the variables in Tables 3 and 4 marked with asterisks all exceeded 20% missingness at that individual time point.

A frequent distinction in the missing data literature is between data which is missing completely at random (MCAR), missing at random (MAR), and not-missing at random (NMAR) (Little & Rubin, 2002). Data are characterized as MCAR if missingness does not depend on the values of any data, missing or observed. The less restrictive MAR assumption specifies that missingness depends only on observed components of the data. Finally, if missingness depends on the missing values of the data matrix, data are NMAR (Little & Rubin, 2002). SPSS 15.0 Missing Value Analysis (MVA) was used to analyze patterns of missing data to determine whether the data should be assumed MCAR, MAR, or NMAR in the complete sample. Exploratory correlation analyses were conducted to determine any traits which should be included in the MVA. In addition to the 24 state fatigue ratings, self-reported sex, mastery, and

Table 3

Percentage of Missing Data at Each Weekday State Attitudes and Fatigue Assessment Time Point

Day	% Data Missing
Monday	
Morning	3.39%
Early Evening	16.38%
Bedtime	14.69%
Tuesday	
Morning	2.26%
Early Evening	15.25%
Bedtime	12.43%
Wednesday	
Morning	3.95%
Early Evening	20.90%[a]
Bedtime	16.38%
Thursday	
Morning	5.65%
Early Evening	24.86%[a]
Bedtime	21.47%[a]
Friday	
Morning	7.34%

Table 3 (continued).

Early Evening	37.85%[a]
Bedtime	31.64%[a]
Week 2 Monday	
Morning	12.99%
Early Evening	27.68%[a]
Bedtime	31.07%[a]

Note. Missing data percentages calculated based on sample in which outliers were not discarded (N = 177).
[a] Time point at which missing data is > 20%..

emotionality scores were included based on weak correlations between these traits and the total amount of missing data. Self-reported trait neuroticism and fatigue were also included in the MVA due to the centrality of these variables to the theoretical issues under investigation. In an effort to determine whether participants needed to be excluded based on their frequency of missing data, the MVA analysis was also run separately on the data set with every participant missing more than 20% of their state fatigue ratings excluded and on the data set with every participant missing more than 30% of their individual state fatigue ratings excluded.

Little's (1988) MCAR test for multivariate data with missing values was used to evaluate the tenability of the MCAR assumption in the complete sample, the sample with participants missing 20% or more of their data excluded, and the sample with participants missing 30% or more of their data excluded. This statistic tests the null hypothesis that the data are MCAR. Little has demonstrated that the null distribution of this test statistic is asymptotically chi-squared, with a failure to reject the null hypothesis indicating that the MCAR assumption is tenable in the evaluated sample. In addition to no clear pattern of missingness being present, Little's MCAR test was non-significant in the complete sample, χ^2 (3338) = 3360.49, n.s., in the 20% or more excluded sample, χ^2 (2335) = 2345.67, n.s., and in the 30% or more excluded sample, χ^2 (2850) = 2875.74, n.s. Given this pattern of results, the data will be assumed MCAR. The missing data mechanism is ignorable and imputation based strategies are appropriate when data are assumed MCAR (Little & Rubin, 2002).

Expectation Maximization (EM) offers a reasonable approach to the imputation of missing values for MCAR data (Tabachnick & Fidell, 2001). EM is an iterative procedure which consists of two steps. The estimation (E) step calculates the conditional expectation of the missing data based on the observed values and the current parameter estimates. The expected values are then substituted for the missing values. Next, in the maximization (M) step, maximum likelihood estimation is performed as if the missing data were filled in (Tabachnick & Fidell, 2001). The process iterates between the E and the M step until convergence is achieved and estimated values change very little from iteration to iteration. One advantage of EM is that variables which are potentially relevant for missingness can be included in the EM algorithm used to impute missing values. In the current study, missing values were imputed using an EM algorithm which included self-reported sex, mastery, emotionality, neuroticism, trait fatigue, and all 24 state subjective fatigue ratings. Separate data sets were created using this EM algorithm for the complete sample, the 20% or more missing excluded sample, and the 30% or more missing excluded sample.

Table 4

Percentage of Missing Data at Each Weekend State Attitudes and Fatigue Assessment Time Point (Non-Imputed Data)

Day	% Data Missing
Saturday	
Morning	18.08%
Early Evening	38.98%[a]
Bedtime	35.03%[a]
Sunday	
Morning	17.51%
Early Evening	29.38%[a]
Bedtime	20.34%[a]

Note. Missing data percentages calculated based on sample in which outliers were not discarded (*N* = 177).
[a] Time point at which missing data is > 20%.

Although MVA analysis did not demonstrate any clear differences between the aforementioned three data sets, a Principal Components Analysis (PCA) was run on the 24 imputed state fatigue ratings to determine if the data sets differed in any significant way. The eigenvalues and loadings of the unrotated principal components in the three samples were then compared to assess the structural similarity of the three imputed data sets. The PCA analysis demonstrated five components with eigenvalues exceeding 1 in all three data sets. The largest observed difference in the percent of variance accounted for by a given principal component across the three data sets was 3.14%, with the rest of the variance accounted for by specific components differing by .34 - .89 %. The largest discrepancy was found when comparing the first extracted components of the complete data set and the 30% or more excluded data set. Inspection of the loadings of the observed variables on the first principal component for these two data sets revealed that the largest loading discrepancy was .09, with all but one difference falling between 0 and .04. Taken together, this pattern of results suggests that discrepancies between the three EM imputed data sets are very minor in nature. Therefore, the complete imputed data set of 176 participants will be used in all subsequent analyses to maximize statistical power[1].

Time of Day Effects

At a descriptive level, it is informative to examine changes in mean fatigue over the course of the day. In the split-plot ANCOVA used to assess the relationship between neuroticism and state subjective fatigue over the course of the day, the main effect of Time of Day was statistically significant, $F(2,173) = 3.91$, $p < .05$, $f = .22$. Tests of within-participant contrasts revealed that the main effect of time of day was defined by a

[1] Results obtained regarding the primary hypotheses in the 20% or more and 30% or more missing excluded data sets were similar. Any discrepancies between these results and the complete data set results will be noted.

quadratic function, $F(1) = 5.84$, $p < .05$, $f = .18$. The form of the Time of Day main effect is shown in Figure 1. The results of post-hoc paired *t*-tests are displayed in Table 5. Effect sizes were calculated using the formula for dependent *t*-tests recommended by Dunlap, Cortina, Vaslow, and Burke (1996). As can be seen from Table 5, subjective fatigue was significantly higher in both the morning and at bedtime than in the early evening.

Table 5

Results of Paired t-Tests Assessing Statistically Significant Main Effect of Time of Day

Assessment Times	M_1	M_2	t	d
Morning vs. Early Evening	3.11	2.79	8.74*	.48
Bedtime vs. Early Evening	3.16	2.79	9.51*	.62

Note. Item-level means are reported.
*$p < .01$

Day of the Week Effects

A set of planned orthogonal contrasts assessing weekday fatigue were tested in a procedure recommended in Cohen et al. (2003). The conservative significance cutoff of $p < .01$ was used to account for multiple tests being conducted. The first contrast compared early weekday state fatigue (Monday and Tuesday) to late weekday state fatigue (Thursday and Friday). This planned contrast was not statistically significant, $F(1, 875) = .59$, n.s. The second planned contrast assessed whether Monday and Tuesday

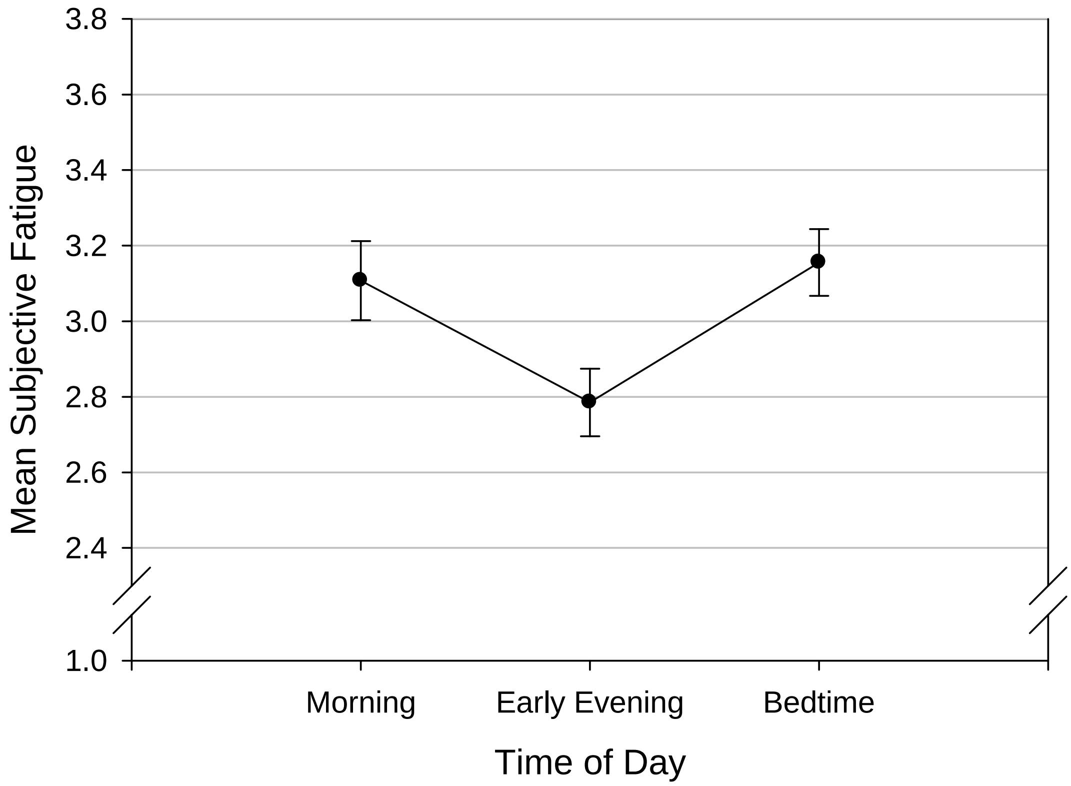

Figure 1. Item-level mean self-reported subjective fatigue levels over the course of the day. Error bars indicate 95% confidence intervals for the mean.

fatigue could reasonably be combined into an early week category. Results of this test indicated no significant differences between Monday and Tuesday state fatigue, $F(1, 875) = .71$, n.s. The third planned contrast evaluated whether Thursday and Friday could reasonably be combined into a late week category. There was no evidence to suggest state subjective fatigue differences on these days, $F(1, 875) = .75$, n.s. The fourth and final planned contrast assessed whether subjective fatigue on Wednesday was significantly different than the average of the other four weekdays. This contrast was not significant, $F(1, 875) = 1.79$, n.s. Thus, Hypothesis 5 received no support in the current study.

Additionally, there was no evidence for an ameliorative role of weekend experiences on fatigue. State fatigue levels were roughly equivalent on Friday and the following Monday, t (175) = .204, n.s. Therefore, Hypothesis 6 failed to receive support. Taken together, these statistical results do not indicate a significant effect of day of the week on state subjective fatigue.

Trait Neuroticism

Results of regression analyses in which neuroticism was entered as a predictor of subjective fatigue are displayed in Table 6. Each regression analysis will be discussed separately in the sections below.

Trait Neuroticism and Overall Fatigue

As predicted by Hypothesis 1, neuroticism was a significant predictor of overall self-reported fatigue over the course of the 8-day study period, $\beta = .42$, $t(174) = 6.10$, $p < .01$. The relationship between neuroticism and fatigue was positive, with participants self-reporting higher levels of neuroticism reporting higher levels of state subjective

Table 6

Results of Separate Regression Analyses assessing Trait Neuroticism as a Predictor of State Fatigue

Predictor Variable	Criterion Variable	*B*	*SE B*	β
Trait Neuroticism	Overall State Fatigue	2.72	.45	.42*
Trait Neuroticism	Morning State Fatigue	1.07	.20	.38*
Trait Neuroticism	Early Evening State Fatigue	.85	.17	.36*
Trait Neuroticism	Bedtime State Fatigue	.80	.17	.34*

*p < .01.

fatigue over the course of the 8-day study period. This relationship remained statistically significant even if sex had been statistically controlled for, $\beta = .39$, $t(173) = 5.45$, $p < .01$.

Trait Neuroticism and Morning Fatigue

Hypothesis 2 predicted that neuroticism would be predictive of self-reported fatigue upon waking. Obtained results support this hypothesis, $\beta = .38$, $t(174) = 5.48$, $p < .01$. Neuroticism and morning fatigue were positively correlated, with higher levels of self-reported neuroticism associated with higher levels of self-reported subjective fatigue in the morning. As with overall state subjective fatigue, this relationship was significant even if sex had been statistically controlled for, $\beta = .36$, $t(173) = 4.89$, $p < .01$.

Trait Neuroticism and Early Evening Fatigue

Neuroticism was also supported as a statistically significant predictor of self-reported fatigue in the early evening, $\beta = .36$, $t(174) = 5.07$, $p < .01$. Again, this relationship was positive. Higher levels of neuroticism were associated with higher self-reported fatigue in the early evening. This relationship held even if sex had been statistically controlled for, $\beta = .33$, $t(173) = 4.48$, $p < .01$.

Trait Neuroticism and Bedtime Fatigue

As predicted by Hypothesis 4, neuroticism was a statistically significant predictor of self-reported fatigue at bedtime, $\beta = .34$, $t(174) = 4.80$, $p < .01$. Participants who reported higher levels of neuroticism reported higher levels of fatigue at bedtime. The relationship between neuroticism and self-reported fatigue at bedtime was also significant if sex had been statistically controlled for, $\beta = .33$, $t(173) = 4.33$, $p < .01$. Taken together, the results of these analyses support neuroticism as a predictor of self-reported state subjective fatigue in the morning, in the early evening, at bedtime, and over the course of the 8-day study period.

The Relationship between Trait Neuroticism and State Fatigue over the Course of the Day

To test whether the relationship between trait neuroticism and state fatigue strengthens over the course of the day, a split plot ANCOVA with time of day as a within subjects variable and trait neuroticism as a between subjects covariate was run. State subjective fatigue in the morning, early evening, and at bedtime were dependent variables. Results of this analysis are presented in Table 7. As mentioned previously, the main effect of Time of Day was statistically significant, $F(2, 173) = 3.91$, $p < .05$, $f = .21$. Examination of results of single-*df* within-participant contrasts revealed that this main effect could be described by a quadratic function with state fatigue higher upon waking and at bedtime than in the early evening, $F(1) = 5.84$, $p <.05$, $f = .18$.

As would be expected from previous results which show that trait neuroticism is a significant predictor of state fatigue over the course of the day, the between-subjects main effect of trait neuroticism was statistically significant, $F(1, 174) = 37.25$, $p < .01$, $f = .46$. Participants with higher self-reported neuroticism reported higher levels of subjective fatigue over the course of the day.

The interaction between trait neuroticism and time of day was not statistically significant, $F(2, 173) = 1.24$, n.s. It is tenable that the relationship between trait neuroticism and state fatigue does not change over the course of the day. Therefore, Hypothesis 7 failed to receive support.

The Relationship between Trait Neuroticism and State Fatigue over the Course of the Week

To assess whether the relationship between trait neuroticism and state fatigue changes over the course of the weekdays and weekends, a split plot ANCOVA with day of the week as a within subjects factor and trait neuroticism as a between subjects covariate was conducted. This results of this analysis are summarized in Table 8. The dependent variables were state fatigue ratings on each of the 8 days of the study period (Monday – Monday). The day of the week main effect was not statistically significant when all 8 days were included in this analysis, $F(7, 168) = 1.87$, n.s. Contrary to expectations, single-*df* tests of within participant contrasts did not indicate that the day of the week effect was defined by a quadratic function, $F(1) = .04$, n.s. The results of the split plot ANCOVA did not provide evidence that state fatigue is statistically different on different days of the week.

Table 7

Results of Split-Plot Multivariate ANCOVA Assessing Neuroticism, Time of Day, and State Fatigue

Source	*df*	*F*	*f*
	Between subjects		
Neuroticism (N)	1	37.25**	.46
S within-group			
Error	174	(12195.46)	
	Within subjects		
Time of Day (T)	2	3.91*	.21
T X N	2	1.24	.12
T X N within-			
group error	173	(2552.62)	

Note. Values enclosed in parentheses represent mean square errors. *S* = subjects.
**p* < .05. ***p* < .01.

Table 8

Results of Split-Plot Multivariate ANCOVA Assessing Neuroticism, Day of the Week, and State Fatigue

Source	*df*	*F*	*f*
	Between subjects		
Neuroticism (N)	1	37.25**	.46
S within-group			
Error	174	(4573.30)	
	Within subjects		
Day of the Week (D)	7	1.87	.12
D X N	7	2.58*	.33
D X N within-			
group error	168	(455.10)	

Note. Values enclosed in parentheses represent mean square errors. *S* = subjects.
**p* < .05. ** *p* < .01.

Consistent with results supporting the relationship between trait neuroticism and overall fatigue, there was a statistically significant between-subjects main effect for trait neuroticism, $F(1, 174) = 37.25$, $p < .01$, $f = .46$. Participants who self-reported higher levels of neuroticism reported higher levels of state fatigue over the 8-day study period.

Finally, the interaction between trait neuroticism and day of the week was statistically significant, $F(7, 168) = 2.58$, $p < .05$, $f = .33$.[2] However, contrary to expectations, a strengthening of the relationship between neuroticism and fatigue over the course of the weekdays and a weakening of the relationship over the weekend was not supported. A graph indexing the relationship between trait neuroticism and state fatigue over the course of the 8-day study period is provided in Figure 2. Table 9 displays statistically significant differences in the strength of the neuroticism – fatigue relationship when comparing specific days. There were two specific factors which contributed to the observed interaction. First, the highest correlation between trait neuroticism and state fatigue was observed on Tuesday. This is inconsistent with Hypothesis 8, which predicted a gradual strengthening of the relationship between these variables over the weekdays. Second, the neuroticism – fatigue relationship was significantly weaker on Sunday when compared to several other weekdays, supporting Hypothesis 9. However, the neuroticism – fatigue relationship was also significantly stronger on Saturday when compared to Sunday, inconsistent with a gradual weakening of the relationship between these variables over the course of the weekend. Thus, Hypothesis 9 received only partial support.

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[2] This hypothesis test did not reach statistical significance in the 20% or more missing excluded data set, $F(7,112) = 1.72$, n.s., $f = .33$. However, as identical effect size estimates and similar trait neuroticism - state fatigue day of the week correlations were obtained in both data sets, the source of the discrepancy is almost certainly due to lower power stemming from the reduced sample size in the 20% or more excluded data set.

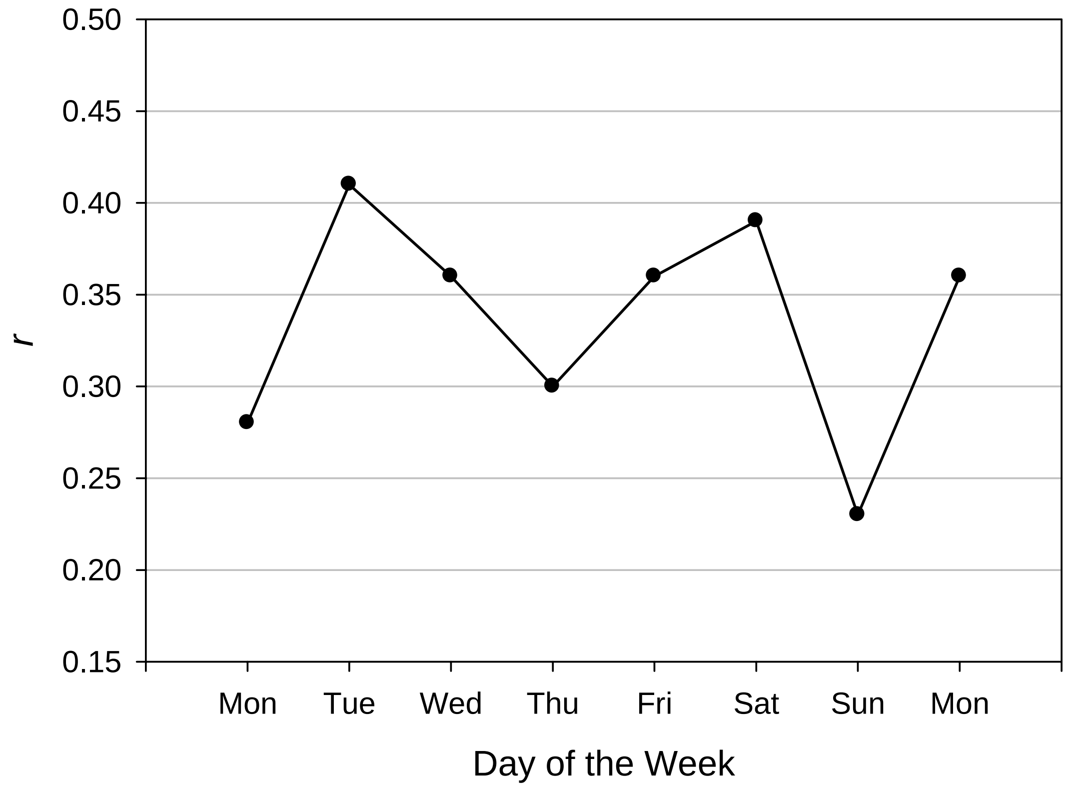

Figure 2. The strength of the relationship between trait neuroticism and state fatigue over the days of the week.

Table 9

Statistically Significant Differences in the Strength of the Neuroticism – Fatigue Relationship on Different Days of the Week

Day 1	Day 2	r_1	r_2	t
Tuesday	Monday [a]	.41	.28	2.12*
Tuesday	Thursday	.41	.30	2.00*
Tuesday	Sunday	.41	.23	2.76**
Sunday	Wednesday	.23	.36	-2.11*
Sunday	Friday	.23	.36	-1.93*
Sunday	Saturday	.23	.39	-2.63**
Sunday	Monday [b]	.23	.36	-2.47**

Note. *d.f.* = 174.
[a] Day one of the study. [b] Day eight of the study.
*$p < .05$. **$p < .01$.

Exploratory Analysis

A set of exploratory analyses were conducted to assess whether any other traits or states were predictive of state subjective fatigue at any of the time points in the current study. As these results were not hypothesized a priori, any significant effects should be interpreted with caution until future studies provide replication. Additionally, a more conservative significance criterion ($\alpha = .01$) will be used as no specific directional predictions were made and multiple unplanned tests were conducted.

Trait Measures and State Subjective Fatigue

Trait Conscientiousness, PA, NA, and Fatigue all exhibited small to moderate correlations with state fatigue on at least one time point. The motivational traits of Desire to Learn, Mastery, Competitiveness, Worry, and Emotionality also exhibited small to moderate correlations with state fatigue at specific time points. However, most of these traits had been shown to correlate with trait neuroticism in the construct validity analysis summarized in Table 1. Therefore, a set of partial correlation analyses were conducted to see whether the aforementioned traits would remain statistically significant predictors of state fatigue after statistically removing the effect of trait neuroticism. Following recommendations made by Stouffer (1936) regarding the effects of inadequate reliability on partial correlation coefficients, correlations were corrected using Stouffer's formula in which there is one measure of two variables (traits in the current study) and multiple measures of a third variable (states in the current study).

Results of partial correlation analyses for traits remaining significant predictors of state fatigue after controlling for trait neuroticism are presented in Table 10. Statistically significant partial correlations are presented on the right hand side of this table. As can be seen from these results, the correlation between several personality traits and state fatigue remained significant after controlling for trait neuroticism. Specifically, Conscientiousness was negatively correlated with fatigue upon waking, fatigue in the early evening, and overall fatigue over the 8-day study period. Additionally, the motivational traits of Desire to Learn, Mastery, and Competitiveness all continued to show small negative correlations with fatigue at various time points. PA was positively correlated with fatigue at all time points studied. Finally, trait fatigue was positively correlated with state fatigue upon waking, in the early evening, at bedtime, and over the course of the 8-day study. The strength of the correlation between trait fatigue and state fatigue is not particularly surprising given that the same items were used to assess the constructs. However, the increased strength of the trait – state fatigue correlation over the course of the 8-day study when compared to at specific times of day does suggest that a trait – state fatigue distinction is appropriate.

Given that trait PA and trait fatigue both remain correlated with state fatigue over the course of the entire day, two separate exploratory split plot ANCOVAs were run to assess whether the interactions between either of these traits and time of day were statistically significant. In the first split plot ANCOVA, time of day was entered as a within subjects factor while trait PA was entered as a between subjects covariate. This analysis yielded statistically significant main effects of time of day, $F(2, 173) = 4.38$, $p < .05$, $f = .23$, and trait PA, $F(1, 174) = 37.95$, $p < .01$, $f = .47$, as well as a statistically significant Time of Day X Trait PA interaction, $F(2, 173) = 3.59$, $p < .05$, $f = .20$. Examination of the nature of the interaction revealed that the relationship between trait

Table 10

Exploratory Partial Correlation Analyses Assessing the Relationship between Traits Measured with In-Lab Questionnaire and State Fatigue when Controlling for Trait Neuroticism

Trait	State Fatigue	Partial *r*
Conscientiousness	Morning	-.32*
Conscientiousness	Evening	-.34*
Conscientiousness	Overall	-.35*
PA	Morning	-.41*
PA	Evening	-.41*
PA	Bedtime	-.20*
PA	Overall	-.46*
DTL	Evening	-.25*
DTL	Overall	-.20*
Mastery	Morning	-.27*
Mastery	Evening	-.26*
Mastery	Overall	-.23*
Competitiveness	Morning	-.21*
Trait Fatigue	Morning	.62*
Trait Fatigue	Evening	.72*
Trait Fatigue	Bedtime	.50*
Trait Fatigue	Overall	.82*

Note. $df = 173$. Partial correlations were computed using Stouffer's (1936) formula for partial correlation in which one variable is measured repeatedly. PA = Positive Affect. DTL = Desire to Learn.
*$p < .05$.

PA and state fatigue was significantly stronger in both the morning, $t(173) = -2.05$, $p < .05$, $d = .11$, and the early evening, $t(173) = 2.03$, $p < .05$, $d = .15$, than at bedtime.

In the second split plot ANCOVA analyzing time of day and trait fatigue effects, the main effect of time of day, $F(2, 173) = 9.80$, $p < .01$, $f = .34$, the main effect of trait fatigue, $F(1, 174) = 103.22$, $p < .01$, $f = .77$, and the interaction term, $F(2, 173) = 3.33$, $p < .05$, $f = .20$, were all statistically significant. The relationship between trait fatigue and state fatigue was stronger in both the morning, $t(173) = 1.68$, $p < .05$, $d = .13$, and early evening, $t(173) = 2.36$, $p < .05$, $d = .15$, than at bedtime.

State PA and State Fatigue Correlations

Given that trait PA is a statistically significant predictor of state fatigue after controlling for trait neuroticism, it is useful to examine whether state PA is related to state fatigue. Although an exploratory technique, cross lagged panel correlation analysis (CLPC) allows researchers to examine patterns of correlations in a longitudinal design (Kenny, 1979). Assuming that X1 and X2 refer to two variables at time 1 and Y1 and Y2 refer to the same two variables at time 2, CLPC generates autocorrelations (X1 and Y1, X2 and Y2), synchronous correlation (X1 and X2, Y1 and Y2), and asynchronous correlations (X1 and Y2, Y1 and X2). Examining patterns in these correlations over time can serve as a test for spurious causation (Kenny, 1979). In the current analysis, autocorrelations, synchronous correlations, and asynchronous correlations were computed for every adjacent state PA and state fatigue measurement (e.g., Day 1 morning and Day 1 evening). To summarize this information in a useful way, average *r*-to-*z* transformed CLPC's were computed for the following time points: (1) Morning to Early Evening, (2) Early Evening to Bedtime, and (3) Bedtime to Morning. Where significant differences between correlations are found, Cohen's q is provided as a measure of effect size (Cohen, 1988). This effect size measure represents the absolute difference between the r-to-z transformed correlation coefficients. Cohen (1988) recommends q values of .10, .30, and .50 as representative of small, medium, and large effects. Results of these three CLPC analyses are presented in Figures 3, 4, and 5.

As can be seen from these three figures, the CLPC relationships appear to be different over different time periods within the day. With respect to Morning to Evening, the synchronous correlations between state PA and state fatigue are quite large in both the morning ($r = -.89$, $p < .01$) and the evening ($r = -.88$, $p < .01$). There were no significant differences in the magnitude of the autocorrelations and asynchronous correlations over this time period, all ts < 1.60, n.s.

The pattern of CLPC relationships changes during the Early Evening to Bedtime time frame. One interesting result is that the synchronous relationship between state PA and state fatigue is significantly stronger in the early evening than at bedtime, $t(173) = 9.64$, $p < .01$, $q = .90$. Additionally, the asynchronous relationship between early evening PA and bedtime fatigue is significantly larger than the asynchronous relationship between early evening fatigue and bedtime PA, $t(173) = 2.13$, $p < .05$, $q = .16$. The asynchronous relationship between early evening PA and bedtime fatigue is also significantly stronger than the autocorrelation between early evening PA and bedtime PA, $t(173) = 1.82$, $p < .05$, $q = .14$. Finally, the autocorrelation between early evening fatigue and bedtime fatigue is significantly stronger than both the autocorrelation between early evening PA and bedtime PA, $t(173) = 2.81$, $p < .01$, $q = .21$, and the asynchronous correlation between early evening fatigue and bedtime PA, $t(173) = 3.13$, $p < .01$, $q = .23$. No other

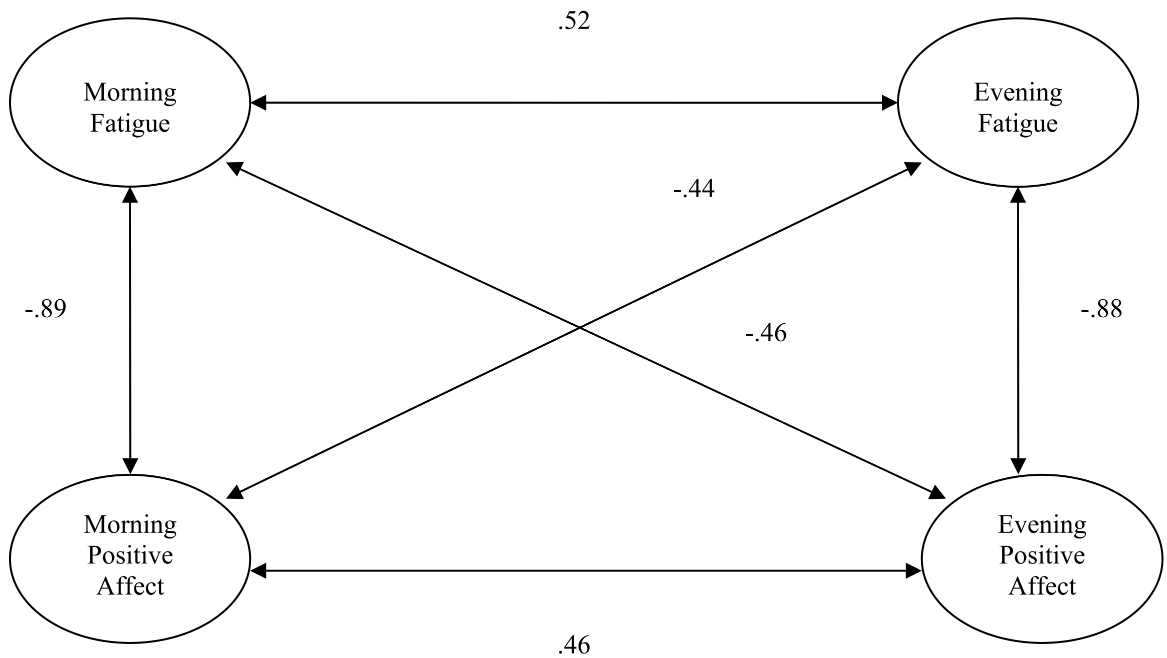

Figure 3. Results of CLPC analysis examining the relationship between state fatigue and state PA from the Morning to the Early Evening.

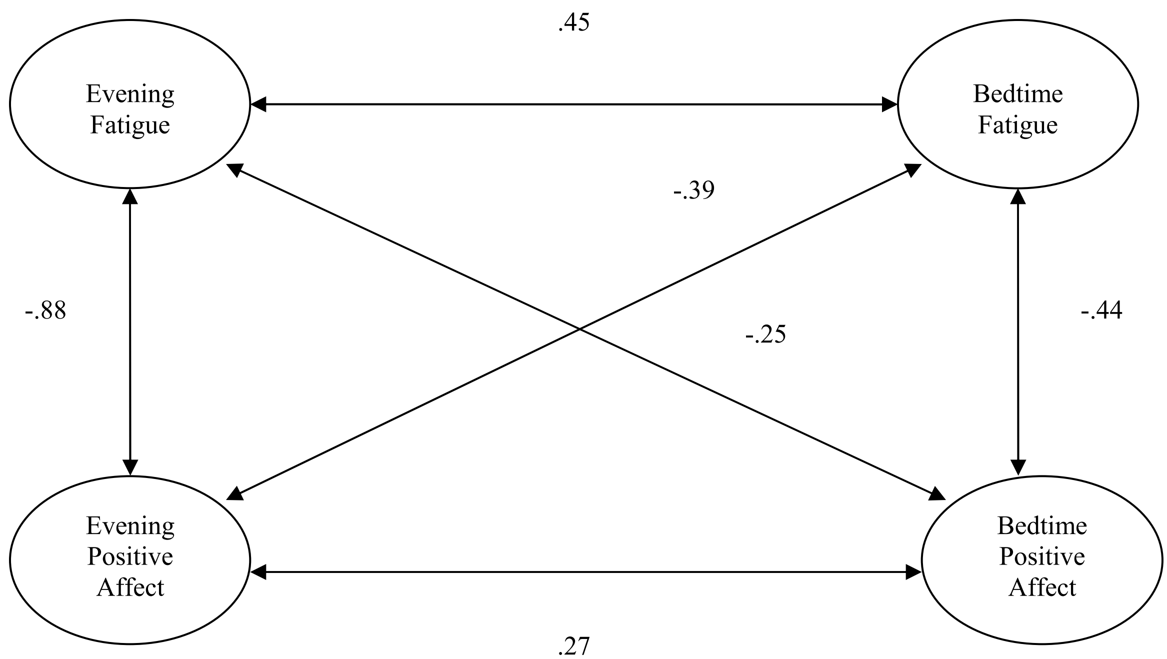

Figure 4. Results of CLPC analysis examining the relationship between state fatigue and state PA from the Early Evening to Bedtime.

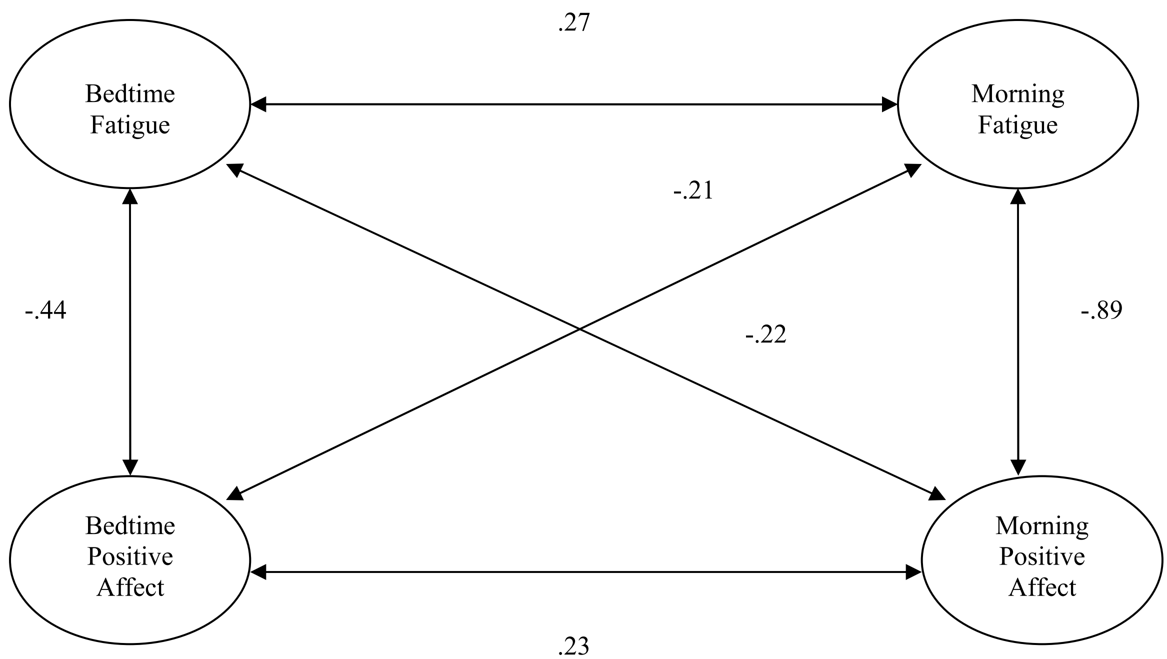

Figure 5. Results of CLPC analysis examining the relationship between state fatigue and state PA from the Bedtime to Morning

differences between autocorrelations and asynchronous correlations were significant in this time frame, all *t*s < .92, n.s.

In regards to the CLPCs over the Bedtime to Morning time frame, the relationship between state fatigue and state PA is significantly stronger upon waking than it is at bedtime, $t(173) = 9.45$, $p < .01$, $q = .95$. While there are no other significant differences between any of the CLPCs, it is interesting to see that both the autocorrelations and asynchronous correlations from bedtime to morning are quite low. It is possible that other factors (such as sleep length or quality), combined with state PA upon waking, exert a stronger influence on fatigue levels upon waking in the morning than state fatigue and state PA experienced the previous night. Average *r*-to-*z* transformed synchronous correlations, asynchronous correlations, and autocorrelations for the three aforementioned time frames are summarized in Table 11.

Table 11

Average r-to-z Transformed Correlations between State PA and State Fatigue in Cross-Lagged Panel Correlation (CLPC) Analysis

Variable	1	2	3	4	5	6
1. Morning Fatigue	-					
2. Morning PA	**-.89***	-				
3. Evening Fatigue	.52*	-.44*	-			
4. Evening PA	-.46*	.46*	**-.88***	-		
5. Bedtime Fatigue	.27*	-.22*	.45*	-.39*	-	
6. Bedtime PA	-.22*	.23*	-.25*	.27*	**-.44***	-

Note. *df* = 173. **Bold =** Synchronous correlation, Plain Text = Asynchronous correlation, Underlined = Autocorrelation. PA = Positive Affect.
* *p* < .01

CHAPTER 4

DISCUSSION

The results of this study provide clear support for the role of the personality trait of neuroticism in predicting elevated fatigue states at several different time points. In contrast to previous studies which have suggested that neuroticism is most predictive of evening and nighttime mood variables (Bohle & Tilley, 1993; Rustings & Larsen, 1998), the evidence presented in the current study suggests that neuroticism is a pervasive predictor of fatigue states over the course of the day and days of the week. Neuroticism was shown to be predictive of state subjective fatigue in the morning, in the early evening, at bedtime, and over the course of the entire 8-day study period. In addition to being a statistically significant predictor of subjective fatigue states, effect sizes for neuroticism as a predictor of state fatigue range from medium to large (r = .34 - .42) according to Cohen's (1988) recommended guidelines. Although neuroticism was supported as a predictor of state fatigue over the course of the entire day, the predicted interaction between neuroticism and time of day was not supported. There was no evidence that the relationship between neuroticism and state fatigue strengthens over the course of the day. Although the anticipated quadratic function indexing the neuroticism – fatigue interaction over the course of the week was not found, there was evidence that the strength of the relationship between trait neuroticism and state fatigue changes over the days of the week. Specifically, trait neuroticism was more strongly associated with state fatigue on Tuesday when compared to several other days of the week. Consistent with expectations, the neuroticism – fatigue relationship was weakest at the end of the weekend on Sunday.

While resource-based approaches to state fatigue would predict a linear increase in fatigue ratings over the course of the day, this pattern of results was not found in the current study. Results indicated that state fatigue could be described by a quadratic function, with higher levels of fatigue in the morning and at bedtime than in the early evening. The time of day effect was of a small to medium size ($f = .18 - .21$), based on Cohen's (1988) guidelines. Two primary conclusions can be drawn from this pattern of results. First, high levels of fatigue were observed at bedtime and upon waking. This is inconsistent with resource based theories of subjective fatigue, which would predict lower fatigue upon waking than at bedtime. Second, the lowest levels of fatigue were observed in the early evening (defined as 4 p.m. – 7 p.m. in this study). There are several possible explanations for this effect. It may be possible that environmental events, such as going home for the day from work or school or eating dinner, temporarily reduce fatigue levels at this time point before returning to higher levels at bedtime. Future research can assess this possibility in a diary approach in which participants are asked to indicate how long they have been home and the types of activities they have engaged in since arriving home. In contrast to an environmental explanation, it is also possible that circadian rhythms may result in lower levels of fatigue in the early evening when compared to the morning or bedtime. In retrospect, it is not surprising that self-reported fatigue is lower in the early evening when compared to the time points during which people are just waking up or about to go to sleep. Finally, it is possible that mid-day naps (a recovery opportunity) led to lower levels of fatigue in the early evening. Pilcher, Michalowski, and Carrigan (2001) found that 76% of young adults reported taking at least one nap during a 7-day period. Given that the current study used college student participants, who likely have more opportunities to nap before the early evening time point than working adults; it is possible that afternoon naps led to lower levels of subjective fatigue at the early evening time point. As there were no specific *a priori* predictions regarding time of day in the current study, future research should examine this main effect directly before more detailed conclusions are drawn.

While previous studies have found significant day of the week fatigue effects (*e.g.*, Nelson & Ladan, 1976), the current study found no evidence for mean differences in state subjective fatigue on different days of the week. Planned contrasts and paired *t* tests failed to demonstrate statistically significant differences in weekday and weekend state fatigue, while the multivariate ANCOVA assessing the role of neuroticism over the course of the 8-day study did not demonstrate a main effect of day of the week. It appears that day of the week exerted very little influence on state subjective fatigue in this student sample. While resource based theories would predict increasing fatigue over the weekdays and decreasing fatigue after the weekend, the current study found state subjective fatigue ratings to be almost equivalent on each day of the week. If day of the week effects are indeed trivial, it may be more economical and informative to investigate subjective fatigue and recovery related variables over the course of the day instead of over the course of the week in future studies. It is also possible that the non-traditional schedules of the student sample used obscured any day of the week effects which may have been found in a working population. Future research should investigate whether day is a significant source of variation in both student and non-student samples. Studies designed to examine fatigue in young adult full-time students, part-time students, and full-time workers would be useful for determining the contribution of work and school to day of the week state subjective fatigue effects.

Given that there was no evidence for mean differences in subjective fatigue on different days of the week, the statistically significant interaction between neuroticism and day of the week is particularly interesting. Neuroticism was most strongly associated with state fatigue on Tuesday. Additionally, while still a statistically significant predictor of fatigue, neuroticism exhibited the weakest relationship with state fatigue on Sunday. The pattern of results displayed in Figure 2 is clearly inconsistent with a strengthening of the relationship between neuroticism and fatigue over the course of the weekdays and a gradual weakening of the relationship between these variables over the weekend. Future research investigating characteristics of specific days which may make them more or less fatiguing would be a good first step towards determining what drives the strength of the neuroticism – fatigue relationship on different days of the week. Although inconsistent with resource based models of fatigue, previous research in a sample of primarily female office workers has found that Tuesday is reported to be the most fatiguing weekday (Nelson & Ladan, 1976). It may be that individuals reporting higher levels of neuroticism are particularly sensitive to the demands and stressors which make specific days fatiguing (see Bolger & Schilling, 1991). Documenting characteristics of days of the week which are particularly fatiguing to different personality types in future studies will allow for the detailed prediction of state subjective fatigue levels from personality traits.

As mentioned previously, the neuroticism – fatigue relationship was observed to be weakest on Sunday. However, the relationship between these variables was still moderately strong on Saturday. An intriguing possibility is that the tendencies of individuals reporting higher levels of neuroticism to ruminate and worry (Muris et al., 2005) leads them to take longer to begin recovering from fatigue states. For example, while less neurotic individuals may be able to begin recovering in their leisure time shortly after leaving the workplace on Friday, more neurotic individuals may not begin recovering from the demands of the week until later in the weekend due to an inability to detach from work (see Sonnentag & Bayer, 2005). Micro-longitudinal designs with frequent fatigue assessments over the course of the weekend could address this prediction directly.

While tentative and exploratory in nature, partial correlation analyses revealed several significant trait predictors of state fatigue at different time points. Conscientiousness, PA, DTL, mastery, competitiveness, and trait fatigue all exhibited significant correlations with state fatigue on at least one time point in the current study. Similar to neuroticism, PA and trait fatigue were significantly correlated with state fatigue at all time points of study. Effect sizes indexing the relationship between these personality traits and state fatigue were moderate to large (f = .47 - .77). Interestingly, exploratory MANCOVAs suggested that the relationship between both of these traits and state fatigue is significantly weaker at bedtime than in the early evening and upon waking. It is possible that personality plays a larger role in predicting fatigue earlier in the day, while external events, such as characteristics of the day at work or school and recovery related activities, are more important in predicting fatigue at bedtime. This possibility is particularly important to study given that the highest levels of mean fatigue during the day were observed at bedtime. This issue could be addressed in future studies using a similar design which also includes questionnaires assessing daily activities and perceptions of the day at work or school.

Exploratory CLPC analyses indicated that the relationship between different states may change over time. Specifically, the synchronous correlations between state PA and state fatigue were very large upon waking and in the early evening, especially when compared to the synchronous relationship between these variables at bedtime. This result, coupled with other statistically significant differences between correlations included in this analysis, suggests that the relationship between state PA and state fatigue over the course of the day should be examined more closely. While results of these CLPC analyses should be viewed as exploratory and interpreted cautiously, it does appear that the relationship between different state variables changes over different time periods of the day. Studies investigating mood related variables without taking into account time of day effects may be missing an important source of variance in mood fluctuations.

At a theoretical level, there are several important conclusions which can be drawn from the results obtained in this study. While previous research has examined both personality traits and environmental variables in relation to subjective fatigue over various time periods (*e.g.*, Hockey & Earle, 2006; Sonnentag, Binnewies, & Mojza, 2008), there are few studies looking at the unique impact of these variables at different specific time points. If subjective fatigue is defined as a state variable which can be altered by circumstances or recovery opportunities (Zijlstra & Sonnentag, 2006), it is important to illustrate the differential impact of different types of variables on state subjective fatigue and recovery from fatigue states. Examination of patterns of statistical significance and effect size estimates suggests that personality traits and time of day are important predictors of state fatigue, while day of the week was not demonstrated to be an important source of variance in reported fatigue. Neuroticism was supported as a moderately strong predictor of state fatigue at all major time points examined in the current study, as were the personality traits of PA and Fatigue. Studies which analyze fatigue at a more descriptive level and fail to include personality variables are omitting a potentially large source of variance in state or trait fatigue.

Results of this study demonstrate that time of day effects should be considered when studying subjective fatigue. While previous research has examined time of day fluctuations in performance (Revelle et al., 1980) and mood (Rustings & Larsen, 1998), less research has focused directly on the subjective experience of fatigue at different times of day. Studies which do examine time of day effects in relation to fatigue often focus on specific groups, such as night shift workers (Bohle & Tilley, 1993). While examining mood under unusual conditions can be useful, the experience of subjective fatigue in normal populations during normal waking hours should not be ignored. The current study suggests that there are significant differences in the experience of subjective fatigue at different points of the day in a non-clinical college student population. Time of day effects appear to be a significant source of variation in the subjective experience of state fatigue.

Although recovery based studies of fatigue have recently begun to use micro-longitudinal designs (*e.g.*, Sonnentag, 2003; Sonnentag & Bayer, 2005), these studies rarely examine the relationship between state fatigue and other state variables at different specific time points. The exploratory CLPC correlations obtained in the current study provide a preliminary indication that the relationship between state mood-related variables may change over the course of different time frames within the day. Examining patterns of change in the relationship between different state variables over different time intervals could be a potentially productive research area which has not been sufficiently investigated in past research. Modern micro-longitudinal designs are well-suited to investigate these types of research problems and should be utilized with greater frequency, especially in the context of fatigue research.

There are several limitations of this study which must be noted. First, the amount of missing data in this study, particularly in the evenings and on the weekend, should not be overlooked. While imputation-based strategies can be usefully applied when the data are assumed to be MCAR (Little & Rubin, 2002), this does not obscure the fact that missing values are being artificially replaced. However, in the current study, Little's MCAR test did not suggest any clear missing data pattern. Use of EM allowed potentially relevant missingness related variables to be included in the imputation strategy (Tabachnick & Fidell, 2001). Future studies with more frequent reminders to participants and less of an opportunity for missing data should be conducted to more precisely assess the pattern and strength of personality, time of day, and day of the week subjective fatigue effects.

Another potential limitation in the current study concerns a frequently mentioned tendency of neurotic individuals to report negative symptoms and health complaints. One author has even defined neuroticism as "the general disposition to develop psychopathological symptoms such as anxiety and depression" (Muris et al., 2005, p.1106). If higher levels of neuroticism lead people to more frequently report negative mood states, it could be the case that this causes them to report more fatigue than other people regardless of their actual level of fatigue. However, there has not been any conclusive evidence that trait neuroticism solely represents a tendency to report psychological and physical problems, as opposed to a personality trait reflecting a tendency to experience negative emotional states (Merkelbach et al., 2003). Given that the construct of neuroticism has been tied to both negative outcomes, such as exhaustion (Michielsen et al., 2007), reduced vigor, and reduced dedication (Langelaan et al., 2006), and negative personality variables, such as anxiety, depression (Muris et al., 2005), and negative affect (Wilson & Gullone, 1999), defining the construct of neuroticism as an underlying personality trait is more parsimonious than conceptualizing neuroticism as a self-report distortion. Until studies demonstrate that neuroticism is a response bias instead of a personality trait, neuroticism should be viewed as a personality trait which is associated with negative affect (Wilson & Gullone, 1999), anxiety (Eysenck, 1991; Muris et al., 2005), depression (Muris et al., 2005), a tendency to experience and be more reactive to stressors (Bolger & Schilling, 1991), and worry-based emotional coping styles (Tamir, 2005). Future research could improve on the design used in the current study by including brief objective indicators of state fatigue along with the subjective fatigue questionnaires. As objective indicators were not used in the current study, results should be interpreted in terms of subjective fatigue only until future studies replicate the observed patterns and associations of this study using objective measures.

Finally, the use of a college student sample may limit the generalizability of the observed findings. While previous research has indicated that college students display comparable levels of exhaustion to other high stress occupations (Law, 2007), research has not been conducted to assess the equivalence of college students to other populations in terms of the subjective experience of fatigue. Future research should be conducted to systematically analyze whether the experience of subjective fatigue is similar in different populations. If it is not, investigating the source of these differences could be a useful means to improve existing theories of fatigue. As only college students were used in the current study, results will need to be replicated in a broader population to determine whether the obtained effects hold in other populations and groups.

Overall, the results of this study suggest that personality, time of day, and state mood variables all play some role in the subjective experience of fatigue. Results demonstrate that neuroticism is a pervasive predictor of fatigue over a variety of time points. Findings also show that the strength of the relationship between neuroticism and fatigue changes over the course of the weekdays and weekend. Exploratory results indicate that trait PA and trait fatigue are good targets for future investigations into temporal fluctuations in state fatigue. Statistically significant differences in mean subjective fatigue were found over the course of day, suggesting that temporal variables should not be ignored in the study of subjective fatigue states. No evidence was found for the role of day of the week in predicting state subjective fatigue. While no specific predictions about correlations between other state variables and state fatigue were made, exploratory CLPC analyses indicate that the relationship between state PA and state fatigue may change over the course of both the day and night to some degree. This study demonstrates that a variety of trait and environmental variables may be important in predicting subjective fatigue states. Future research should investigate the interplay between personality, time of day, and mood in predicting temporal fluctuations in both objective and subjective indicators of fatigue.

APPENDIX A

The IPIP – Neuroticism Subscale

1. I often feel blue.
2. I dislike myself.
3. I am often down in the dumps.
4. I have frequent mood swings.
5. I panic easily.
6. I am filled with doubts about things.
7. I feel threatened easily.
8. I get stressed out easily.
9. I fear for the worst.
10. I worry about things.
11. I rarely lose my composure (Reverse scored).
12. I remain calm under pressure (Reverse scored).
13. I am not easily frustrated (Reverse scored).
14. I seldom get mad (Reverse scored).
15. I am relaxed most of the time (Reverse scored).
16. I am very pleased with myself (Reverse scored).
17. I am not easily bothered by things (Reverse scored).
18. I rarely get irritated (Reverse scored).
19. I feel comfortable with myself (Reverse scored).
20. I seldom feel blue (Reverse scored).

APPENDIX B

Weekend Activities Questionnaire

1. Studied for a test
2. Engaged in a hobby
3. Did homework for school
4. Went to a party or social gathering
5. Read for fun
6. Listened to music
7. Exercised
8. Worked on a group project for school
9. Went to lunch or dinner with friends
10. Went shopping
11. Worked at an off campus job
12. Called a family member
13. Utilized relaxation techniques, such as yoga or meditation
14. Engaged in outdoor activities
15. Played sports
16. Went to a concert
17. Attended a religious service
18. Slept late
19. Played video games
20. Shopped on the internet
21. Watched TV

22. Went to a movie

APPENDIX C

Orthogonal Contrast Codes Used to Test Weekend Subjective Fatigue Effects

	Monday	Tuesday	Wednesday	Thursday	Friday
Contrast 1	-1/2	-1/2	0	+1/2	+1/2
Contrast 2	-1/2	+1/2	0	0	0
Contrast 3	0	0	0	-1/2	+1/2
Contrast 4	-1/4	-1/4	1	-1/4	-1/4

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